ANNUAL REPORT OF PROGRESS

REHABILITATION ENGINEERING

REHABILITATION ENGINEERING CENTER

OF

THE SMITH-KETTLEWELL EYE RESEARCH FOUNDATION

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REHABILITATION ENGINEERING CENTER

OF

THE SMITH-KETTLEWELL EYE RESEARCH FOUNDATION

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Core Area of Research:
Sensory Aids for the Blind, Visually Impaired, and Deaf-Blind

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INTRODUCTION

The core area of research for the Smith-Kettlewell Rehabilitation Engineering Center is sensory aids for the blind, visually impaired, and deaf-blind. The past year has seen major progress in all project areas, including the following outstanding highlights:

Our new "SKERF-Pad" computer access system for the blind, representing a breakthrough in cost and ease of use, has been reduced to IBM-compatible form and field-tested.

The first prototype Flexi-Meter for general-purpose job instrumentation for the blind has been built and is undergoing testing.

The first complete Dotless Braille communication system for those with reduced fingertip sensitivity has been completed.

A Polaroid version of our Photographic Vision Screener has been developed and is undergoing field testing in a pediatric clinic.

A new hybrid Fresnel/Conventional optical reading aid has been built for low vision reading.

Progress in these and many other projects is described in the following sections of this progress report.

A. VOCATIONAL AIDS

1. INNOVATIVE COMPUTER ACCESS APPROACHES

a. Touch-Pad Computer Access System ("SKERF-Pad")

The "SKERF-Pad" is a talking computer-screen reader for the blind (Figure 1) which uses a touch-pad to represent the screen. This concept, developed by our consultant Mr. William Loughborough, is a revolutionary step forward in computer access for the blind. It allows the contents of any desired part of the screen to be "read" in synthetic speech by pointing to the corresponding area on the touch-pad. A specially designed overlay (produced by vacuum thermoforming) is used on the touch-pad to guide the user's fingers along raised horizontal lines corresponding to lines of screen text. The overlay, costing only a few cents to produce, fits directly over the "Touch Window" - a commercially available page-sized touch-pad costing approximately $250.

This year, the software has been converted on schedule to a resident program for IBMs and clones, and the resulting system has matured into a product that is being successfully used by an employee of the California Public Utilities Commission in San Francisco. Her suggestions have contributed to new features and an improved touch-pad overlay design.

Figure 1. New "SKERF-Pad" Computer Screen Reader for the Blind

With the current version of the device (1.14) the user can instantly read any character or word at any position on the screen, read the balance of the selected line, the balance of the page (screen), or review the last five characters that were typed in.

In "words" mode, one can easily read either a word, a line, a page, or a column of figures (as on a spreadsheet). Also, the position of the "voice cursor" can be spoken as coordinates (as can any point touched - in "coordinates" mode), and the screen cursor can be moved to the voice cursor.

Compatibility with WordStar, PC Write, Lotus 1-2-3, and DOS has been proven, and it will soon be tested with SideKick and other resident programs. Beta tests are being conducted by blind users including the Research & Development Committee Chairman of the National Federation of the Blind. Evaluation is also under way at the Central Blind Rehabilitation Center of the Veterans Administration Hospital in Hines, Illinois.

The issue of speech quality has been examined by the blind evaluators. Their consensus is that the rather primitive quality of the Echo synthesizer is quite acceptable, since with a few hours' use one learns to understand it. The low cost of the Echo appears to outweigh the better initial intelligibility of more expensive synthesizers.

The option of placement of the touch-pad in a vertical orientation on the screen or on a horizontal orientation on the table or desk beside the keyboard is provided by the Touch Window used in the system. Either position is easily user-selected; however, to date no blind user has chosen placement on the face of the monitor screen, since this appears to be considerably more awkward for accurate and comfortable touching than use of the pad flat on a desk or table.

Commercial distribution of the system is being investigated by our consultant in conjunction with the Personal Touch Corp., manufacturers of the touch-pad (Touch Window), who have generously cooperated in furnishing devices and technical help.

An alternate synthesizer (Synphonix by Artic) which permits software control of reading speed and the option of improved speech quality is being interfaced with the touch-pad for future testing.

In summary, the past year has seen the development of a commercially feasible hardware/software combination screen reader that will permit blind users to access regular software without modifying the software or the computer. All the devices used in the system are relatively inexpensive off-the-shelf components. The screen overlays are made on a Thermoform machine and the software is constantly being improved, with particular emphasis on implementing design suggestions made by the users. Retail cost of the add-ons for an IBM or clone will be less than $600 for synthesizer, touch-pad (with game port card), overlay, and software.

The new system was the subject of a special article in the July 1987 issue of Technology Update, published by the Sensory Aids Foundation.

b. Mouse for the Blind

We explored the possible use of the "mouse" pointing device as a means of computer access by the blind. Our investigation of the practical problems involved led to several conclusions, listed below.

Use of the mouse with voice output appears problematical from the point of view of human factors engineering. There are potential difficulties in keeping the synthetic speech "in sync" with mouse movements of varying speeds and directions. The mouse approach is currently being tested by Energy Materials Research Inc. and Berkeley Systems Design. Since the announcement by IBM of their single-cell braille mouse, we have been in communication with them in order to avoid duplication of effort. Their design is considered proprietary, but we intend to monitor progress to determine whether any complementary development work on our part is justified.

Our own tentative conclusion is that a single cell may provide some utility, but that in order to simulate adequately the feeling of finger "movement" over a braille page, a really effective braille mouse display may need several (perhaps 5) high-speed refreshable cells. Alternatively, a cell-sized array of many (perhaps 20) finely spaced high-speed pins which rise and fall sequentially may be needed to create smooth motion. These approaches, however, would require considerable technical development in order to provide the required refresh speed.

In view of these considerations we plan no duplicate effort, but will continue to monitor and evaluate the emerging technology in this field.

2. SMITH-KETTLEWELL VOLATILE BRAILLE DISPLAY

The new low-cost refreshable or "volatile" braille display being developed in our laboratories has progressed rapidly this year. We are pleased to report that the major sensory aids manufacturers are expressing serious interest in commercial production when development is completed.

The device uses low-cost electromagnetic technology combined in a unique proprietary design to result in a simple-to-manufacture unit which eliminates the need for fabrication of the many different parts required by currently manufactured displays.

a. Evaluation of First Prototype

As a result of our mechanical and electrical tests on the first prototype (the construction of which was described in last year's report), a number of problem areas were identified for atten-

tion. Principal among these were the reset, the design of the electromagnet coils, and problems with braille dots sticking in the down position. In seeking solutions to these problems, a radical improvement and simplification of the design was achieved and an upgraded prototype constructed.

A new three-cell prototype (Figure 2) was built to make certain these radical design changes described would result in a workable device before attempting a full-sized version. Initially, one full cell of this prototype was wired up with coils and driving circuitry for testing.

b. Evaluation of Upgraded Prototype

The upgraded prototype has been tested by eight blind individuals with the following results:

Criterion	Number Reporting Difficulty
Dot height	2
Dot uniformity	1
Uniformity of background	1
Resistance to deformation	2
Degree of sideways play	0
Speed of operation	0
Display temperature	0
Tactile comfort	0

The results indicated that the main factors needing modification involve the perceived height and the resistance to deformation of the dots. Those subjects who expressed reservations on this score agreed that the difficulty would be obviated if the ends of the braille pins were made smaller in diameter, thus making the dots "sharper" and improving readability.

c. Evaluation of Commercial Feasibility

Details of the display have been shared confidentially with several well-known sensory aids manufacturers. All have expressed the opinion that the outlook for commercial feasibility is excellent, assuming the remaining development work is successful, and have expressed a desire to make use of the invention either through producing it themselves or purchasing it from an outside manufacturer for incorporation in their products. Correspondence and discussions are now ongoing to determine the best approach to commercialization and the stage of development at which the various possible manufacturers would be willing to take over.

In addition several members of our Scientific Advisory Board have been consulted on the commercial feasibility question, including Dr. Emerson Foulke (Perceptual Alternatives Laboratory, University of Louisville), Mr. Tim Cranmer (Technology Committee,

National Federation of the Blind), and Dr. John Gill (Royal National Institute for the Blind). All their opinions on the subject have been positive with respect to the potential marketing of the device both in the United States and in Europe.

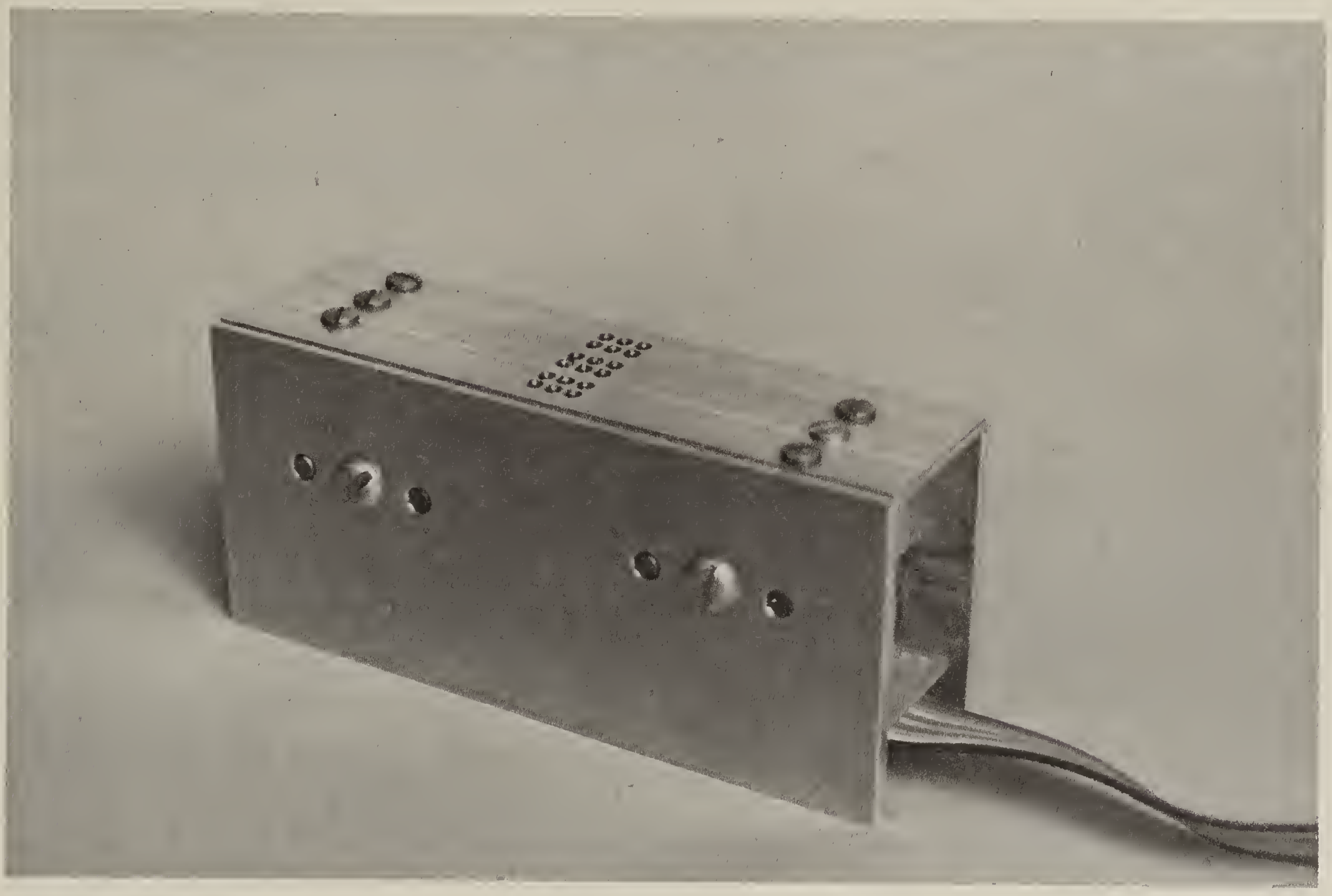


Figure 2. Redesigned 3-Cell Braille Display Module

3. FLEXI-METER

The Flexi-Meter is a universal job instrumentation system for the blind under development in our laboratories. The system, fully described in our 1986 progress report, will enable information from many different measuring devices used in various job situations to be processed and presented auditorily for the blind employee.

An engineering prototype of the Flexi-Meter (Figure 3) has been designed and constructed. After testing the basic boards, the prototype was packaged for testing in and out of the laboratory with various transducers. The unit meets or exceeds all original specifications and has both physical room and memory space for expansion as necessary. Extensive software development has taken place, and the device has been bench-tested and demonstrated in our laboratories and at the RESNA Conference (June 1987).

Also in June of 1987, we were able to obtain, with the help of Mr. Jack Brown at "FOG" (First Osborne Group), a microprocessor in-circuit emulator. This device allows the software (actually called "firmware" since it is stored in memory chips) for the Flexi-Meter to

be tested and debugged (during development) as it operates on the actual unit, allowing much more rapid software development.

Subsequent to the in-house bench-testing, refinements are now being added to the software to allow the unit to be "self-programmed" through the use of its built-in keypad. The user will make selections from spoken menus allowing the setup of from 1 to 9 separate scales. Parameters available for setting include: the word to be spoken as each scale is selected, the source of data for each scale (analog or digital inputs, etc.), the scaling and zero offset factors for each scale, and the output mode for each scale (voice, Morse Code, or serial port for braille display, etc.).

A number of special functions will be available for use when appropriate. These will include, but are not limited to: automatic indication (beep) that a reading has exceeded a preset value, and automatic reading taken upon occurrences such as changing data.

**Figure 3. Prototype Flexi-Meter:
A Universal Job Instrumentation Device for the Blind**

The unit will shortly be tested in job situations with blind users drawn from industry. In outside workplaces, the physical size of the engineering prototype may make it somewhat obtrusive. This, and the necessity for quick-in, quick-out adaptation to on-site instrumentation, may make temporary on-the-job installations difficult. However, several mock set-ups will be created in the laboratory and/or at selected workplaces in which blind employees will be asked to evaluate

the Flexi-Meter's operation in situations where they are familiar with other adaptive devices.

Modifications based on user feedback from these tests will ensure that the Flexi-Meter serves its function without being overly complex to operate. Such feedback will also allow both the developers and the intended users to make better assessments of the machine's potential applications and limitations.

4. BRAILLE NOTETAKER

A second prototype Note-a-Braille was completed in January this year. This unit incorporated a number of improvements over the first prototype.

The prototypes are being loaned to various interested persons for evaluation. We have written an extensive questionnaire (Appendix A) which is being distributed to users of the Note-a-Braille, including at least two individuals who have constructed their own units using our plans - one in England and one in South Africa. As of this date we have received a number of informal comments on the device - all generally very favorable. Questionnaires are now being returned, and initial responses from the first two returns indicate that users appreciate the simplicity and low cost of the device, and wish for very few, if any, additional features. Evaluations of the responses will be made to assist with our assessment of commercial feasibility as well as any final needed improvements.

Two interested groups have indicated a desire to design a printed circuit board for the device with a view to making it widely available; however, they have not yet produced their versions. In the meantime, we have purchased a computer-aided design system for printed circuit board layout and manufacturing. With this system we can do the PC board layout on an Apple Macintosh and then send a copy of the computer file to the PC board manufacturer for fabrication. We have been familiarizing ourselves with the system by designing boards for some of our simpler devices. This experience will enable us to do a PC board design for the Note-a-Braille if the interest from the groups mentioned above does not translate into a production version of the device.

We are currently exploring the commercial feasibility of the device. Simultaneously with the development of the Note-a-Braille, three other research groups (two in the United States and one in England) designed devices which initially appeared to use similar principles, but our analysis of these devices indicates that they do not fulfill the same criteria as those originally laid down in our Note-a-Braille concept. Both U.S. versions incorporate a speech synthesizer and considerable supporting hardware and software for text editing, resulting in expensive systems. In contrast, our original concept was to provide a relatively inexpensive pure data entry and storage device, and leave data processing functions to the personal computer. The projected production and marketing costs for the Note-a-Braille are approximately 50% of those for the English version and 25% of those of the United States versions. Consequently, the prospects for commercial

production appear favorable. The trade-offs as perceived by users between cost and additional features is addressed in our survey (see Appendix A).

5. SPECIALIZED AIDS AND DEVICES

a. Audible Line-Voltage Monitor

The development of this device was requested by a blind appliance repairman in Rosemead, California. There are occasions (particularly in old houses) when the capacity of the electric utility service is so low that home appliances interfere with each other - especially where one of the appliances contains a microprocessor. Traditionally, a sighted repair technician observes a visual line-voltage meter while the various appliances are manipulated. This blind repairman had a talking digital meter which, for other applications, is a highly accurate tool; however, its announcements are much too slow for temporary changes in line voltage to be detected. He expressed a need for an audible indicator which could be monitored much like the equivalent visual analog line-voltage meter.

Coincidentally as this request was received, an outside contributor to The Smith-Kettlewell Technical File, Mr. Bernie Vinther, submitted a design for a simple and highly portable "qualitative circuit analyzer" which produces a variable-frequency tone output. We were able to modify this design to perform the line-voltage meter function, and with the addition of a full-wave rectifier on the input - and selecting two input resistors, one for 120 volts and one for 240 volts - the specialized appliance voltmeter was completed.

The device (Figure 4) uses a 555 timer IC as a voltage-controlled oscillator (VCO) to produce an audible tone whose pitch varies as line voltage fluctuates. The advantage of the "qualitative circuit analyzer" design on which this unit was based is that, like the visual line-voltage meters, its "voltage window" over which the circuit operates can be restricted. This has the benefit of making the VCO very sensitive over a small range of voltages, the threshold being relatively high. In our prototype, for example, the VCO does not operate until an input voltage of 60% of that selected for monitoring has been reached. The tone reaches a value of about 2kHz within the normal range of voltages encountered.

If this device proves useful it has commercial potential, not only among blind electrical workers, but for their sighted counterparts. For the sighted, this auditory output device would be a light-weight, low-cost alternative to expensive "strip-chart" line monitors; the point being that active visual monitoring of a volatile display is not necessary (the voltage being assessable by ear). We plan to publish an article on this device in a popular journal in order to reach this broader audience.

Figure 4. Audible Line Voltage Monitor

b. A New Soldering Iron for the Blind

Our work on developing techniques and tools for soldering by blind individuals is on-going. Commercial soldering irons maintain a high temperature (343 deg.C. minimum). While adaptive techniques have proven themselves in safe handling of hot irons, some blind technicians have expressed a desire for a quickly heating iron that could be positioned on the work when cold. (A device with this criterion was available in the 1950s. Called a "soldering gun," a power transformer was used to heat a hairpin wire tip which could be positioned before being energized. However, a small version of this design was never commercially realized, thus preventing its use on modern circuitry.)

A significant new soldering tool was suggested by a reader of our information forum, The Smith-Kettlewell Technical File. In its simplest form, it is an AC-adapted "cordless" (originally battery-operated) iron. Called the "Vinther Fingertip Soldering Iron" (after its inventor, Mr. Bernie Vinther), this device (Figure 5) has undergone further development in our laboratories.

In adapting the iron for use by blind people, the heavy battery-containing handle of the commercial version is not used. Instead, the tip assembly is powered by wires from a 2.5-volt transformer whose primary circuit contains a foot switch.

Since this iron heats up very quickly, the iron and solder can be positioned while the tip is cold, thus eliminating the need for a guide altogether. With this tool, it is also easier to ensure that the positioning of a hot iron does not endanger nearby components or wires.

Through tests in our laboratories, some disadvantages of the basic Vinther design have become evident:

The tip assembly is quite fragile. If held against connections with too much force, the bond between the metal tip and a ceramic insulator behind it fractures; once this bond has been broken, damage to the heating element soon follows.

The heat capacity of the tip is sufficient to maintain injurious temperatures for as long as 20 seconds. Thus, the system of placing the iron in position when it is cold places serious practical limits on rapidity of operations.

In the original implementation, this device had no temperature control; therefore, if power is left on longer than is necessary, the tip can quickly become so hot that corrosion of metals and damage to the work pieces results. This also carries potential danger to the user. This disadvantage can be partially offset by careful

Figure 5. New Soldering Iron for the Blind

monitoring of solder flow - either by noting a decrease in length, or by other related cues (smelling smoke from the flux, experiencing a "squeaky" feeling that results when flux has made the metals clean of oxides, or noting a sharp temperature rise of connected components as alloying occurs).

We have done preliminary work to design a temperature controller for this iron. By monitoring the tip current with 2.5 volts applied, it was found that the tip resistance varies through a range of 0.3 to 0.63 ohms. Since tip resistance is a function of temperature, the initial work on a controller was based on a four-arm bridge circuit. One arm (R1) of the bridge is the soldering iron itself. A second arm (R2) is a sampling resistor. These two arms are in series across the power supply. The remaining two arms (also across the power supply) consist of a fixed-value resistor (R3) and an adjustable one (R4) for setting the temperature. The voltage between the junction of R1 and R2 and junction of R3 and R4 is the error signal and is used to control the system.

In our implementation, the sampling resistor (R2) and the control device is a single unit. This is a recent development from Motorola with the trade name Sensefet - a power field effect transistor (FET) with an additional terminal at which a voltage proportional to current through the FET is available. This is equivalent to the sampling resistor R2 described above, but with only a fraction of the power loss associated with a practical valued real resistor. The error signal is applied to a feedback amplifier and fed to the gate of the power FET.

Initial bench tests indicated the practicality of this scheme, and further work is planned to finish and test the design.

c. Auditory Carpenter's Level

A new auditory level was designed in 1986 with a number of advantages over existing devices (see 1986 Progress Report). Three prototypes were produced; two of these are now in the hands of blind users. One of these users is a rehabilitation counselor in Southern California who requested our prototype to assist him in building custom cabinetry in his home. He has expressed complete satisfaction with the instrument, which he has been using for four months.

Before the design could be published, the visual instrument (the "Levelite") from which the unit was adapted was transferred to a new manufacturer, who withdrew it from production due to calibration problems (drying of cement on the sensor caused a shift in calibration, and there was no electrical means to correct for this shift).

As of September 1987, the new company (Fourth Corner International of Bellingham, Washington) had redesigned the device. Consultation with their engineer has been very fruitful, and it is projected that we will be able to fabricate three or four new adapted prototypes by the end of 1987. Desirable new features suggested by the previous evaluation will be included. For example, a "silence" switch

has been found to be necessary because the visual instruments have no convenient means by which their circuits can be turned off (the "on" switch is a 2-minute timer which cannot be overridden or disabled), and blind users find the continuation of the tones after taking measurements to be an annoying feature.

d. Ultrasonic Measurement Device

The feasibility of designing an ultrasonic tape measure equivalent for use by the blind was investigated. The need for such a device was brought to our attention by blind persons engaged in carpentry. We established the following criteria which would need to be met by any such device:

(1) Accuracy at short distances is of little advantage since excellent devices already address this issue - the "Click Rule" from the American Foundation for the Blind (AFB), for example. The necessity for a measuring tape stems from addressing high accuracy at long distances (2 meters or more). Therefore, if the accuracy of a proposed design could not be better than 1/4 inch over long distances, the system would not present sufficient advantage over the current AFB Braille tape measure.

(2) The procedures for use of the instrument would have to be simpler than those required in using the AFB Braille tape measure.

Our feasibility study showed that both criteria were difficult to meet simultaneously with current ultrasound technology. A "time of flight" system, wherein the return of an echo would be timed, is handicapped by the fact that the amplitude of the echo would be unknown. This results in an unpredictable detection of "onset" which leads to errors in time. In other words, as the amplitude of the detected signal fades, the point of its waveform that exceeds the triggering threshold changes, and the error encountered becomes a function of distance.

Counting wavelengths would probably result in the best accuracy (limited by the resolution presented by the wavelength). The greatest stumbling block in this approach is that (in its simplest implementation), once a zero crossing is counted, there is no way of "uncounting" it. The burden would, then, rest on the user to assure that the distance only increases; even aligning a unit with the end of a plank might violate this rule. In addition, interference from standing waves could be anticipated.

One scheme contemplated (which could overcome this problem) would have involved measuring the phase of counters operating from a transmitter and a receiver. This system would permit very high accuracy at long distances, but a precise "standard" distance would be necessary to work from. In other words, this scheme would not provide a way of determining "absolute distance." A further difficulty is that the velocity of sound changes significantly as a function of temperature - over 3% for a change of 20 deg.C. Any ultrasonic system would have to compensate for this.

Upon completing the feasibility study, we concluded that while some combination of methods might be arranged to take advantage of this ultrasonic technique, procedural complexity was foreseen. Optical detection of the markings on a standard or modified tape measure has not yet been tried to our knowledge; as primitive as this appears, this may represent a more feasible approach at this time.

6. DEVICE EVALUATIONS

a. VTEK BDP "ACT II" Braille Display Processor

The BDP is a braille output access system for the IBM PC (also available for the Apple II). Since we published a detailed evaluation in a previous progress report, a discussion of its specific features and merits will not be repeated here. The BDP "ACT II" is a modified and improved version of the original unit, and its changes will be discussed here as evaluated by our staff.

Because of technical difficulties with earlier braille displays, the manufacturer had to change to a new display system. This unfortunately required a reduction from eight- to six-dot braille and necessitated the inclusion of several new modes of operation to allow the user to access information about "attributes" such as upper/lower case or the presence of control characters. The new display is relatively slow in setting up a 20-character line of braille. While the display is being reset, the operator's fingers must not touch the dots, or if so only very lightly. Excessive pressure causes errors in the braille. Also, the size of the braille is somewhat larger than standard. These problems increase the length of time required for new operators to become facile with the system.

A significant improvement in this unit is the Audio Cursor Tracking (ACT) feature. The ACT allows the operator to move the computer's cursor to the position of the braille display without removing his hands from the computer's keyboard. This feature causes the BDP to emit two beeps if the cursor moves away from the display position, and one beep if the movement is closer. These beeps are somewhat longer than necessary, and the use of a single tone frequency output device means that the presented information must be interpreted over time. If the output had differing pitches for "closer" and "farther," the speed of use would be increased by an average of 25%. However, the inclusion of this feature dramatically increases the usability of the unit in applications such as word processing where it is often necessary for the operator to move the cursor to a point where a correction or insertion needs to be made.

As mentioned above, a number of features have been added to allow the user to determine the attributes of characters on the screen. They allow the user to determine the case (upper or lower), the presence of control characters, and in some cases the presence of characters from the ASCII graphic character set. The read-out for these characteristics is coded through different rates of protrusions and retraction of the particular braille cell in question. These functions are toggled on and off through multiple presses of combinations

of buttons on the BDP's control panel. As it is possible for the user to select among a range of "flash rates," the process of learning the meaning of the various flashes, especially when several of these functions are on at once, can be intimidating. However, these functions are absolutely necessary for successful access to the computer screen without eight-dot braille.

In conclusion, the BDP ACT II is a successful access system for the IBM PC family of computers at its current level of development, excluding systems which depend upon graphic output. It is even possible for the experienced user to determine some characteristics of simple "character-oriented graphics," with the unit's flash functions. As the BDP is transparent to the computer, there are rarely, if ever, difficulties encountered with incompatibilities between the user's applications software and the access system. This is still a notable problem with access systems based on software included in the host computer.

B. RESEARCH FOR THE MULTIHANDICAPPED

1. "DEXTER": A MECHANICAL FINGERSPELLING HAND FOR DEAF-BLIND USERS

a. Software Development

This year, efforts have been directed toward refining Dexter to simplify the finger movements in preparation for more extensive evaluation by deaf-blind subjects. This work is being carried out in conjunction with the Veterans Administration RR&D Center. Dr. Deborah Gilden of our staff is defining the letter-pair transition movements and Dave Jaffe of the Veterans Administration is providing the programming to eliminate the neutral position between all letter pairs. This will make the system faster and more fluid, as well as consistent with standard fingerspelling done by humans. The process requires the manual specification of the finger movements for every possible transition from one letter to another, and incorporation of this information into the driving software.

b. Hardware Simplification

A second goal has been exploring the feasibility of simplifying the hardware configuration of Dexter to reduce the number of fingers and joints as well as its functional mechanical complexity. Our earlier feasibility study indicates that a reduction in number of fingers and/or joints should not reduce the intelligibility of the system. Testing this theory using Dexter itself is dependent on the current software developments. Meanwhile, we have held discussions with experts in manufacturing and materials to pursue further the possibility of a low-cost, simplified Dexter. Approaches under consideration include the use of nitinol, a memory metal alloy, to provide motive power and replacing the solenoid valves, pneumatic cylinders, and cables used in the present system. The primary concern with this design is the limited maximum speed of response. Our nitinol consultant, Dr. David Johnson, is presently conducting studies which address the speed question relative to the use of the material in this and other devices. If nitinol is determined to be too slow, we believe simple, low-cost electric solenoids or stepper motors may suffice to substitute for the complex pneumatic system presently employed. Our engineering plan for an improved, less expensive prototype will shortly be complete. A decision on whether to proceed with fabrication will depend on the results of the planned Dexter field evaluations.

c. Interfacing

Progress has also been made toward another goal - interfacing Dexter to various computers and computerized systems. A rare opportunity is presenting itself toward this end. Science Applications International Corporation (SAIC) of Annapolis, Maryland, has developed a device called the Braille TeleCaptioning System (BTS) which enables deaf-blind individuals to "watch" captioned TV via braille output. Through the combined technical expertise of SAIC and the Veterans

Administration, we are going to attempt to interface Dexter to the BTS. It may be feasible to demonstrate this at the California State University, Northridge, Conference on Computer Technology, Special Education and Rehabilitation in mid-October. At least one deaf-blind consumer will be available to try the system at that time and make evaluative comments.

d. Related Developments

(1) Fingerspelling Glove

Dexter has sparked the birth of other communication devices for deaf-blind people. One which appears to hold especially good promise is a "fingerspelling glove" with synthetic speech output and braille feedback. This is being developed by James Kramer, a graduate student at Stanford University. The glove enables a deaf or deaf-blind fingerspeller to have his hand configurations interpreted by a computer system, and then appear on a computer monitor, articulated word for word by a speech synthesizer, and confirmed via braille feedback on a wearable braille display. We have consulted regularly with Mr. Kramer regarding the development of his system, which will make its public debut at the Northridge Conference. We believe that the combination of Dexter, the BTS, and the fingerspelling glove will represent the most comprehensive two-way communication system for deaf-blind individuals in existence.

(2) Oaktree Mechanical Hand

The development of another mechanical fingerspelling hand has been initiated by a commercial concern, Oaktree Automation, Inc., in Arlington, Virginia. It is based on a fingerspelling hand developed in 1981 as a master's thesis project. As a result of communicating with this company, we were given the opportunity to view the functioning of their original hand on videotape. We made the following observations comparing the Oaktree prototype with Dexter:

(a) A cord ("tendon") is required between the thumb and index fingers on the Oaktree hand; Dexter's digits are all supported independently.

(b) Both systems return to the neutral position between letters, but the Oaktree hand seemed to spend more time in the neutral position than in the letter configuration position.

(c) The Oaktree hand appeared to be slower than Dexter.

(d) The Oaktree hand has no buffer memory, so the entry of each letter on the interfaced keyboard must await the completion of the previous letter.

(e) The use of nylon rather than metal, and the great attention to anatomical detail, make the Oaktree hand more humanoid than Dexter.

(f) Additional wrist flexibility allows the Oaktree hand to form the letter "p," which Dexter is unable to achieve at present.

We have discussed the above list with Oaktree personnel. They were aware of the listed advantages and disadvantages of their system. They had already corrected some, and have plans in place to correct others.

We are holding discussions with Oaktree with a view to hastening the appearance of a commercial product through the mutual sharing of accumulated information and experience with the respective hands. It currently appears possible that Oaktree may be able to use our results and designs to assist them in bringing a commercial version of a fingerspelling hand to market.

2. DOTLESS BRAILLE READER

The concept of the Dotless Braille reader (a device for presenting braille to those with poor tactile sensitivity) was described in last year's Progress Report. The development project is proceeding on schedule, and the following milestones have been achieved.

a. <u>Investigation of Alternate Solutions</u>

During the past year, we were told that a device manufactured in Finland called the "Dialogos" was essentially identical to our proposed Dotless Braille Reader. We have investigated this and have learned that the Finnish device is very different from the one we have developed. Although Dialogos also separates the braille cell dots so that there is a single dot under each of six fingers - three on the left hand and three on the right - these "dots" are mechanical pins which require good tactile sensitivity (perhaps even better than that required for reading standard braille). The entire concept of the Dotless Braille Reader is to eliminate the need for good tactile sensitivity by employing the kinesthetic sense. Thus our system utilizes large round buttons to represent the braille dots, and their activation is detected when they push the fingers up.

b. <u>Full-Scale Prototype Design and Fabrication</u>

Our pre-prototype unit consisted of only two buttons - one which moved up and one which dropped down. We fabricated it to determine which direction of excursion was preferred by blind users. The choice of upward motion was virtually unanimous. We subsequently completed fabrication of a complete-cell prototype Dotless Braille Reader (Figure 6). We chose to build an 8-button rather than a 6-button version to allow the reader to access computer braille. During the presentation of standard materials, the extra buttons (one on each end) remain dormant. The Reader is currently interfaced with an 8-key electronic braille keyboard, from which it receives information.

Information concerning the required upward key force and movement distance was obtained from the pre-prototype. Optimal key

spacing was determined according to standard typewriter key spacing and the preferences of our blind staff and students. This resulted in the following specification:

Initial upward force	5.0 ounces
Required vertical displacement	0.15 inches
Key spacing	0.75 inches

It was decided to provide input directly from a corresponding braille keyboard, rather than a computer, to maximize direct interaction between subjects and the experimenter. In order to achieve this it was necessary to design a suitable interfacing circuit. Since solenoids develop their maximum force at the end rather than the beginning of their travel, the circuit had to provide a large enough initial current surge to lift the keys off their rest positions with the necessary 5-ounce force. However, the current must then taper off as the solenoid plunger moves up in order not to exceed the overall power dissipation ratings of the solenoids. The latter were necessarily limited in size and capacity by the required key spacing dimensions. These problems were successfully overcome and a working unit meeting the specifications was produced.

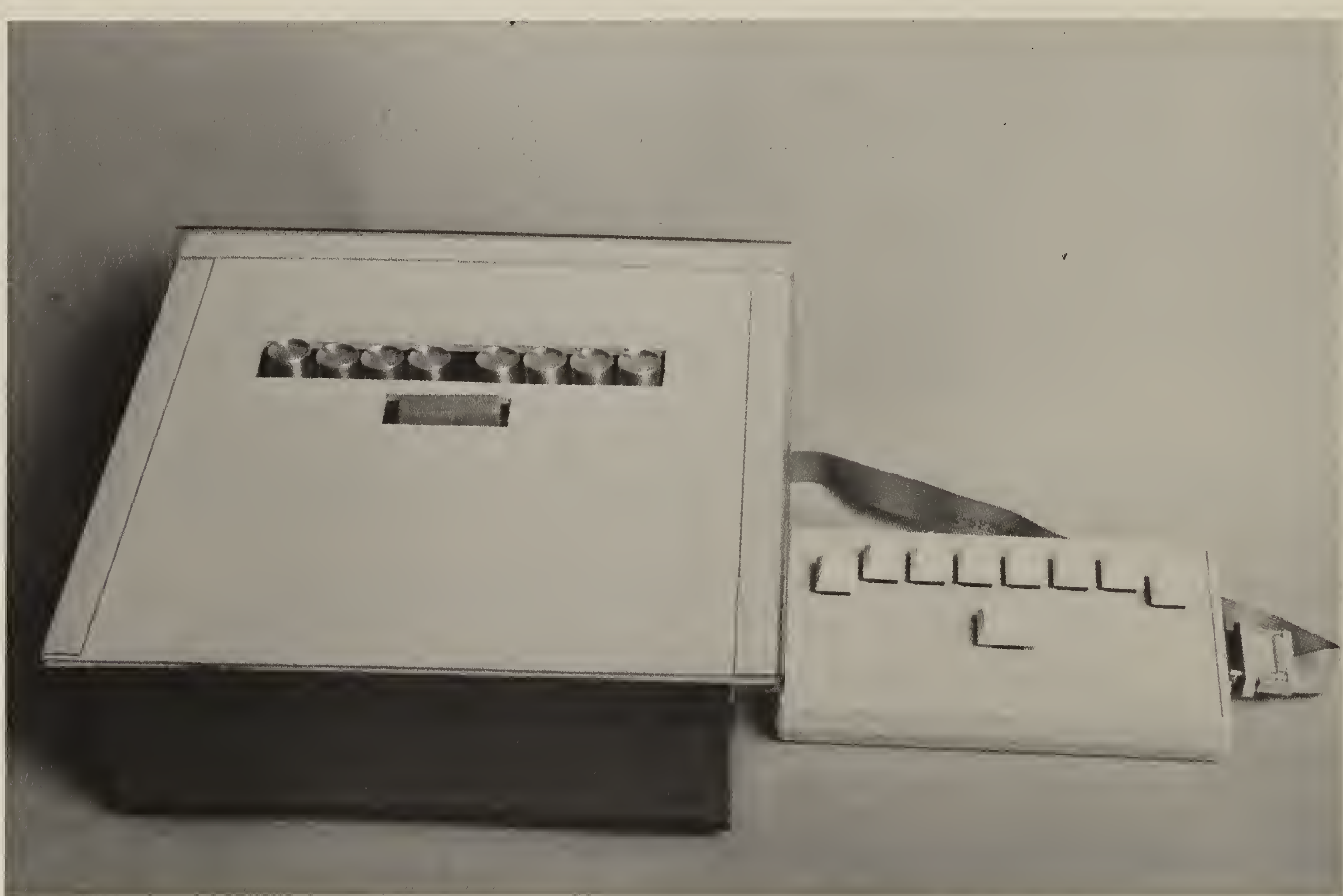


Figure 6. Dotless Braille

c. Feasibility Evaluation

Informal usage by blind staff and students at the Smith-Kettlewell Rehabilitation Engineering Center, none of whom have degraded tactile sensitivity, has indicated that (1) this method of reading braille code kinesthetically does allow for the transfer of the information, and (2) at least initially this is a much slower process. This latter finding is not at all surprising. In fact, we have the impression that this multi-finger system of reading requires an entirely different skill from the standard braille reading method. It may be that a new motor-cognitive neural complex is involved in interpreting kinesthetically received information compared to tactilely received information. Paul Bach-y-Rita, M.D., an expert on brain plasticity and sensory substitution, concurs with this hypothesis. We are determining how much improvement in speed is achieved by skilled braille users through a limited amount of practice with the Dotless Braille Reader. We also plan testing with deaf-blind subjects and with blind subjects, whom we have identified, possessing reduced tactile sensitivity. This will allow us to determine the system's apparent effectiveness with different population groups, its probable applications, potential production costs, and potential for commercial exploitation.

In addition to these evaluation studies, we have prepared for more extensive formal testing and development contingent on the final results of the current feasibility evaluation. The research protocol for these formal studies of the system has been approved by the Joint Council on Human Research, and testing materials have been chosen.

3. PROGRAMMABLE VIBRATING REMINDER FOR DEAF-BLIND USERS

The modified prototype Programmable Vibrating Reminder for deaf-blind users (Figure 7) received further evaluation this year. The modifications we had requested were carried out by the unit's designer, Mr. Herb Cohen, and the ensuing evaluation was designed to determine whether a commercial version of the device in its present form would be feasible. Our results are detailed below.

a. Vibrating Unit Wearability

In response to our request to increase the "wearability" of the cigarette-pack sized unit to be carried by the user, Mr. Cohen added a plastic clip. This appears to be a satisfactory solution to users who are wearing slacks, skirts or belts.

b. Ease of Setting Time Intervals

Simplifying the procedure to set the alarms has resulted in making this relatively easy. Changing an alarm time, however, is a more formidable task as it requires knowledge of the alarm settings programmed to go off between the current time and time of the alarm to be changed. This is required because the alarm to be altered is called up by its number - which is an ever-changing value as the next scheduled alarm is always labeled "zero" and the subsequent alarms are

labeled "1" through "9." For example, once alarm 0 is signaled and over with, what used to be called alarm #1 becomes alarm #0, what was alarm #2 becomes alarm #1, etc.

c. Ease of Confirming Alarm Settings

Both the hardware and software design of the Programmable Vibrating Reminder render confirming the time settings a difficult task. It requires the deaf-blind user to get the feedback from the vibrating tactor built into the side of the programming unit. This method was originally chosen to minimize cost by keeping the number of mechanical vibrators needed down to an absolute minimum - namely one.

Figure 7. Programmable Vibrating Reminder

The deaf-blind person is required to use his left hand to hold down the number of the alarm he wants to confirm, use his right ring finger to hold down the vibrotactile pushbutton, use his right index finger to "read" the signal from the vibrotactile pin, and then release the number key and subsequently release the vibrotactile pushbutton. While changes to the hardware and software could alleviate the complexity of this process, the user must also have the long- and short-term memory capacity required to decode and retain the read-out. The read-out consists of a series of different frequencies and duration of vibration of the tactor to represent P.M., hours, minutes, seconds, and the the value of "0." The user must count the number of vibrations at each frequency and retain this information throughout the read-out process in order to know what time was set for each alarm queried.

This readout procedure was determined to be too complex for practical use, but correcting this would entail a major redesign with different software and a larger number of vibrotactors. For these reasons such a modification was not attempted as a part of this evaluation.

d. Cosmetic Acceptability

The vibrating unit, containing the vibratory signaling device, is small and quite wearable. Its cosmetic acceptability is on a par with "beepers" commonly worn by physicians.

e. Usefulness

There is little doubt that a vibrating reminder would be an exceedingly useful tool for deaf-blind people as they are unable to utilize the natural sound, light, and activity pattern cues which mark the passage of time. The Programmable Vibrating Reminder is sufficiently difficult to program, however, that a different design concept may be in order. For example, the single tactor read-out is unacceptably demanding on short-term memory. A series of tactile displays, one indicating A.M. or P.M., the next indicating hours, and the next indicating minutes, would solve this problem. Using single vibrating tactors in each location might be adequate, but pop-up pins to be counted or print number configurations would be faster to read and less demanding of short-term memory. However, this would greatly increase the cost of the unit.

A more minor problem is the difficulty of interfacing and disconnecting the portable unit and the programming unit; a toggle switch is required to be in one position during the coupling and uncoupling procedures, but must be in another position during the programming process. Failure to correctly position the switch causes the system to malfunction. This would be relatively easy to convert in a final design.

f. Commercial Potential

Given the limitations of the current design discussed above, we concluded that the device in its present form is not commercially promising as a product for deaf-blind people. If operation of certain features could be made simpler, however, the result would be a most useful sensory aid for deaf-blind individuals. Ironically, such a new design would probably greatly increase the cost of the system due to the need for more expensive and numerous tactile indicators (enabling use of an easier-to-understand read-out code) and more sophisticated hardware and software to make the read-out process more "user friendly."

It should be noted, however, that because the sighted user can read the liquid crystal display relatively easily, a version of the Programmable Vibrating Reminder may be of great benefit to the deaf community.

4. FUNCTIONAL VISION ASSESSMENT IN USHER'S SYNDROME

We have completed the planning for a pilot study to develop improvements in the clinical examination of deaf patients with progressive retinal disorders (usually Usher's Syndrome). The examination of these patients is presently often inadequate because of (1) the communication problems that exist among the patient, the interpreter and the ophthalmologist, and (2) incomplete current knowledge about the eye disease and the exact nature of the retinal changes it produces. Our first priority is to address the communication problem so that greater understanding of the other problems can follow.

In this effort we are collaborating with Dr. Lea Hyvarinen, a member of our Scientific Advisory Board and internationally renowned expert in low vision and the deaf-blind. Dr. Hyvarinen has informally explored combinations of conventional sign language and other special tactile signs and cues for use in the specialized environment of the ophthalmologist's office during an eye examination. This work has revealed the need for re-educating, with suitable training materials, the patients, sign language interpreters, and medical specialists to improve communication. Pilot study materials for the patients and interpreters have been written in Finnish and need to be translated into English. Video films depicting the communication process during the visual examination have also been tested by Dr. Hyvarinen as training tools.

During a four-week visit to SKERF in March 1987, Dr. Hyvarinen prepared for the study by exploring subject availability, writing the manuscript <u>Eyes And Vision</u> for educating subjects and interpreters, and discussing the experimental design with REC staff. It was decided to incorporate considerably more tests in the examinations than first envisaged, including several developed at SKERF. Arrangements were made to hire an interpreter/research assistant for the project to assist in the practical logistics of communicating with the subjects, to interpret during the various tests, and to help analyze the videotaped results. The formal testing of approximately 50 deaf-blind subjects will commence in November 1987 when Dr. Hyvarinen joins our staff for a 6-month period in order to undertake the study. Dr. Gilden of our staff has obtained the cooperation of the Helen Keller National Center and local agencies in the recruiting of patients. Examination results should provide much-needed clinical data on which rehabilitation approaches can be based, as well as lead directly to improved methods of assessment of Usher's Syndrome patients.

5. ADAPTATION OF THE VESTIBULO-OCULAR REFLEX

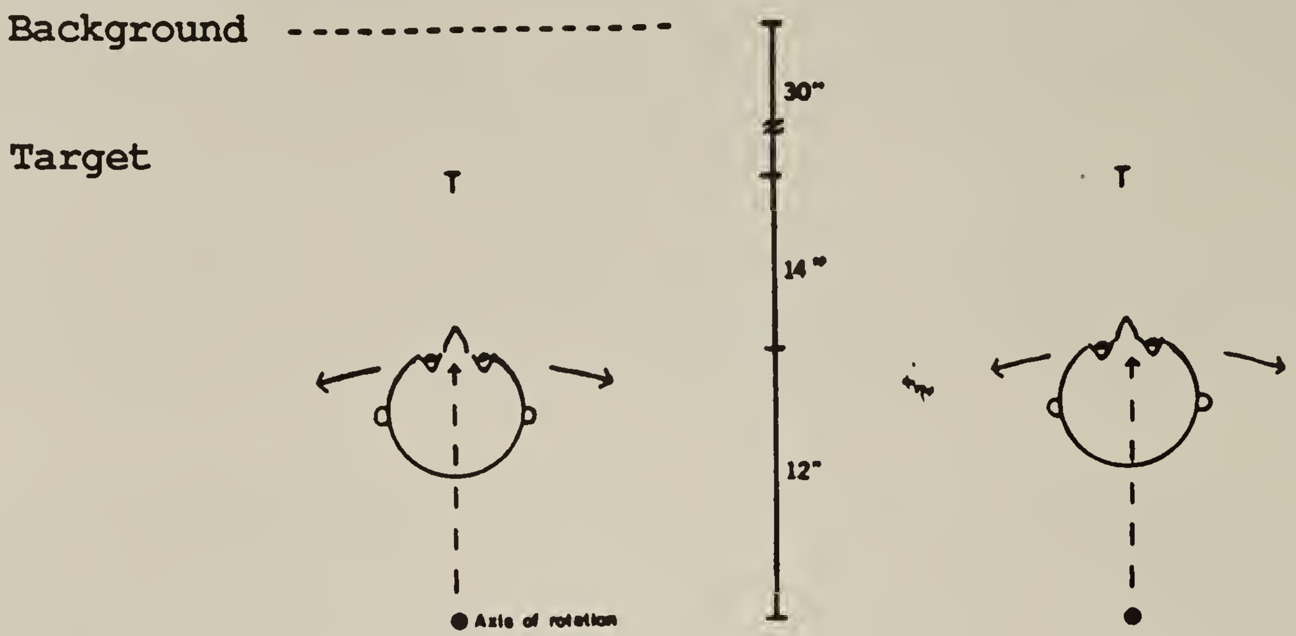
When we turn our head, our eyes rotate almost instantly in the opposite direction, by an amount nearly equal to the head rotation. These eye movements, known as the vestibulo-ocular reflex or VOR, keep images stable on the retina. If the VOR does not adequately stabilize vision, our world appears to move every time our head turns. This in turn produces debilitating symptoms similar to motion sickness, including dizziness and nausea.

Adaptation is an important property of the VOR. It enables the VOR to remain calibrated and stabilize vision throughout life in spite of growth, aging, disease, injury, and even changes in optical magnification from optical aids. As such, controlled adaptation can become a useful component of diagnosis, treatment, and rehabilitation of VOR disorders.

During the last year, experiments concerning the treatment and rehabilitation of VOR disruptions were run. The purpose of the experiments was to determine which components of the visual world activated adaptation, and whether a method of activating adaptation comfortably and rapidly could be developed.

The experiments showed (a) that motion of a full field background, similar to background motion parallax, activated VOR adaptation more strongly than a small target of interest, and (b) that adaptation could be comfortably and rapidly activated. The method is depicted in Figure 8. Subjects were slowly rotated about a vertical axis while they fixated a target 14" in front of them. A textured background was visible 30" behind the target. Because the axis of rotation was behind the head, subjects were exposed to an increased amount of background motion parallax. This visual stimulus activated on average a 20% adaptive VOR gain decrease on (see Figure 9).

The results demonstrate the feasibility of controlling adaptation using a procedure that can become an acceptable component of a treatment and rehabilitation program. Additional experiments are needed to determine whether adaptive gain increases can be activated, and also to determine whether the method is an effective way of reducing symptoms related to VOR deficits.



8a. Near target, far stripes

8b. Near target, no stripes

Figure 8. Diagram showing the position of the subject, target, background, and axis of rotation.

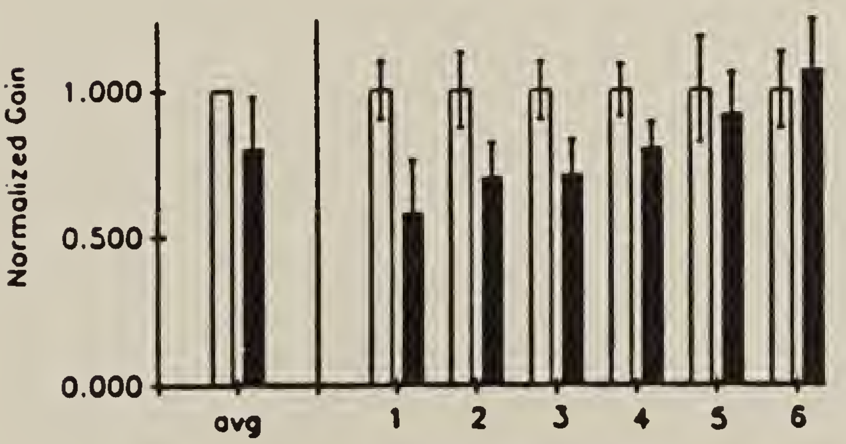


Figure 9a

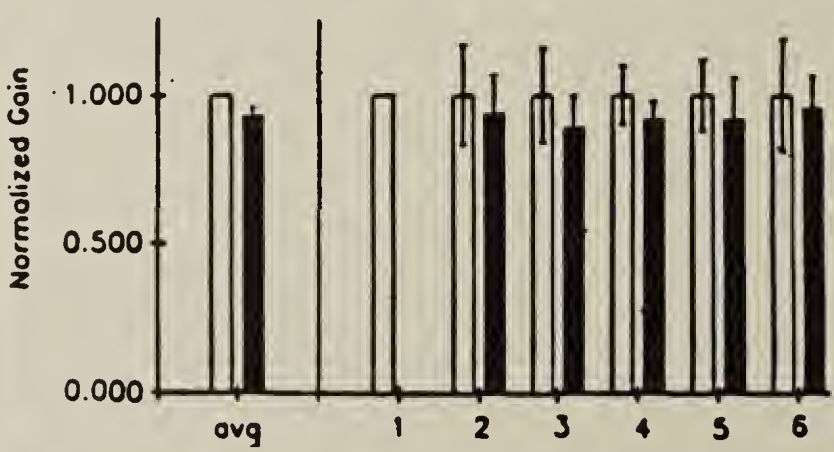


Figure 9b

VOR gain before and after adaptation session a) with background motion parallax; b) without background motion parallax. Filled bars 1 - 6 show gain for each subject after adaptation session. Average gain was 0.8 for sessions with background (see Xa. "avg" filled bar), and 0.92 for sessions without background (see Xb. "avg" filled bar).

C. EDUCATIONAL AIDS

1. INTRODUCTION

There is a new trend in education to go back to basics in terms of "hands-on" learning, but this time with high tech. This approach is reflected in articles appearing in both the technical press (e.g., "Why Most U.S. Students Can't Get Into Engineering School," IEEE Spectrum, August 1987, pp. 28-32) and the popular press (e.g., "Now Even Lego is Going High-Tech," Business Week, August 17, 1987, p. 40). This hands-on/high-tech philosophy - portrayed as new - has been the basic principle for the design of educational toys and other educational materials developed at our Rehabilitation Engineering Center for many years. It is reflected in the devices developed to be used by blind and other disabled youngsters, in the electronics training kit we developed for blind adults, and in the hands-on vocational training program for blind people conducted for several years at Smith-Kettlewell facilities.

The renewed commercial emphasis on electronic toys, but with the hands-on twist, is most encouraging to our efforts to locate a manufacturer for the educational materials we have developed. In fact, our Tact Tell System represents a hands-on approach which far exceeds that advertised by new commercially available systems such as the Lego System, where all that is literally "hands-on" is typing on a computer keyboard. The Tact Tell System, in contrast, presents tangible materials for the user to not only explore but to actually manipulate in conceptually meaningful ways. There is no need to have direct interaction with the computer via the keyboard except to boot up the disk and indicate the level of difficulty of the questions, and there is no need to interact with the monitor as the system was designed for visually impaired children and therefore employs a speech synthesizer to replace the monitor.

2. FLEXI-FORMBOARD

The Flexi-Formboard (Figure 10) is the first educational toy developed at the Smith-Kettlewell Rehabilitation Engineering Center to achieve the sought-after goal of commercialization. This electronic formboard is scheduled to be manufactured and distributed by Adaptive Communications Systems, Inc. ACS is a rapidly growing company which specializes in communication aids for non-speaking children and adults, and has recently added adapted toys for physically disabled children to its product line. We are most pleased that ACS is providing the mechanism to make the Flexi-Formboard available to disabled children.

3. TACT TELL SYSTEM

The concept of this new interactive computer-based educational aid is described in earlier reports; the following is a brief summary of progress this year.

Figure 10. Flexi-Formboard Production Prototype Fabricated by Adaptive Communications Systems, Inc.

a. Tact Tell Map

(1) Introduction

A prototype Tact Tell Map has been fabricated and represents, to our knowledge, the world's first "talking map." It comprises a 6-piece wooden puzzle map, an Apple Computer, a speech synthesizer, and appropriate software (Figure 11). The pieces represent Greenland, Canada, Alaska, the remainder of the United States, Central America and South America. To accommodate users with low vision, each piece is painted a high-contrast color to make it easily differentiable from other pieces and from the blue "water" background.

The user may choose any of five levels of difficulty. The simplest level is designed for very young sighted children or others who have limited vision as it requests the user to insert geographical pieces by color. The name of each piece is incorporated into the feedback from the computer via the speech synthesizer in response to the insertion of each piece.

Levels 2 through 5 present a variety of geography questions which require no vision. An example of an easy question is "Insert the piece called 'the United States.'" An example of a difficult question is "Put in the area that contains Mt. McKinley." The

user's name is incorporated into each question - e.g., "Susan, put in the country that contains provinces." Questions were chosen with the assistance of a blind educator who teaches geography to blind students.

The system monitors the user's responses, including noting if more than one piece is inserted, or if any pieces already correctly inserted have been removed (which is not allowed). An example of a correct answer is "Good for you! South America is the correct answer."

Evaluation of the module via classroom testing sessions has begun, and feedback from special educators is being incorporated into the next iteration of the device.

Figure 11. Tact Tell Map

(2) Technical Description

The map circuitry was designed to detect and store any transitions that occur to the puzzle piece locations on the map. Each puzzle piece location on the map has a magnetically actuated proximity switch; each puzzle piece has a magnet embedded within. The magnet activates the proximity switch when the piece is in the puzzle and the circuitry records this transition for detection by the program.

Two major constraints have dictated most of the circuit design:

-- Transitions on the map could occur at anytime.
-- The Apple computer only has the capability to sense external changes through the game port when it is running a program that is explicitly checking for these changes (polling mode).

As a result of the first constraint, all transitions must be latched (for future reading by the program) and synchronized for the polling program (because they could occur simultaneously with the polling). The proximity switch signals are debounced through Schmitt triggers and then latched and synchronized by D-type flip-flops. The second constraint requires the Apple computer to poll the game inputs to detect any changes. The Apple program detects the state of each switch by sending a series of signals to the 3-to-8 decoder (74HC138), which in turn enables buffers (74HC125). As each buffer is enabled, its signal is sent to the 10-to-4 priority encoder (74HC147). Thus the active or inactive proximity switch signal is encoded on the 3 input lines to the Apple game port, which are read by the program.

b. Tact Tell Shape Sorter

The electronic and mechanical design of the Shape Sorter has been completed, and fabrication is well advanced. The physical base and wooden shapes have been constructed, and some of the electronic components and wiring are in place (Figure 12). Upon completion, it will serve as an excellent complement to the Tact Tell Map in the evaluations planned for next year.

Figure 12. Tact Tell Shape Sorter

c. <u>Investigation of Commercial Feasibility</u>

One of our activities this year has been to explore the commercial potential of the Tact Tell concept. Production cost projections are in preparation for the map module; however, no commercial commitment has been sought or obtained at this early stage. Researching of articles such as those referred to above, the positive reactions of all persons so far involved in testing the prototype, and a number of contacts with companies involved in manufacturing and marketing, have suggested a high probability that a commercial product based on the concept should ultimately be feasible.

D. ORIENTATION AND MOBILITY

1. INFORMATION USED IN MOBILITY: Study of Stationary Pedestrians at Intersections

In collaboration with Dr. Emerson Foulke, Director of the Perceptual Alternatives Laboratory, Louisville, Kentucky, we completed and analyzed the first two studies in our series of experiments aimed at determining the information needed for good mobility. These initial experiments involved the collection of data from blind and sighted subjects at intersections, as a precursor to the next series involving subjects moving through an extended mobility task. The intersection is a critical factor in the process of orientation and mobility, and represents a good starting point for our studies.

Study Number 1

Five sighted individuals standing at a street intersection were asked to enunciate all features of the visual environment they thought significant to the problem of beginning locomotion across the street, along the sidewalk on the other side. Subjects' comments were recorded on tape and transcribed for analysis to give a breakdown into categories of available information. The following is a brief summary of the types of information recorded.

1. Wind direction
2. Traffic flow (sounds and visual images)
3. Traffic light changes
4. Sidewalk directions
5. Presence and type (house, church, etc.) of buildings around intersection
6. Presence and size of tree across street
7. Presence and positions of parked cars
8. Presence, positions, and heights of curbs and ramps
9. Nature of road and path surfaces
10. Presence and travel directions of pedestrians
11. Street signs (no parking, crosswalk, stop, etc.)
12. Telephone poles
13. Types of passing vehicles
14. Street widths and number of lanes
15. Presence of pedestrian crossing control buttons
16. Lines painted on street surface

Study Number 2

The above procedure was repeated with three blind pedestrians, who were able to report the following classes of features from their initial stationary position (subjects were allowed to tap the ground in front of them with a cane). Care was taken to ask the subjects how they

detected each piece of information. Subjects who were generally acknowledged to be skilled travelers were chosen in order to fix the upper limits of information detection by the blind using their unaided senses and the long cane.

	Information	Method of Detection
1.	Width of roads at intersection (no. of lanes)	traffic sounds
2.	Presence, type (left turn, etc.) and timing of traffic signals	traffic sounds
3.	Type of street (one-way or two-way)	traffic sounds
4.	Specific movements of individual cars (crossing intersection, turning corners, etc.)	traffic sounds
5.	Presence and travel direction of pedestrians	footstep sounds
6.	Presence and approximate height of buildings across the intersection	traffic sounds (reflected and "shadowed")
7.	Presence and approximate height of buildings behind subject	cane echolocation
8.	Presence and extent of curb cut	cane contact
9.	Wind direction and intensity	touch and hearing
10.	Sun direction	facial heating
11.	Difference in surface texture of sidewalk and road	cane scanning
12.	Identification of passing vehicle types (bus, truck, car, etc.)	traffic sounds

The blind subjects were subsequently allowed to move around the sidewalk in the immediate area of the corner, and were then able to detect the following environmental features.

	Information	Method of Detection
13.	Presence of telephone pole	cane contact
14.	Presence of signs	cane contact
15.	Presence of other possible obstacles (fire hydrant, etc.)	cane contact

Discussion

Although much of the information gleaned by the blind subjects was not surprising, some categories were unexpected in their presence and accuracy of detail. For example, the ability to detect the presence and even the height of buildings across the street exceeded our expectations. Overall, there were few relevant categories of information perceived by the sighted subjects but not the blind ones; however, the blind subjects were generally less reliable and precise in some categories.

Considerably more data were collected than are presented here; the above is only a brief summary. In particular, after each experimental session we asked the blind subjects a series of questions regarding the methods they would use to detect particular environmental features while walking. This information was collected to assist with the design of the next studies in the series.

In addition, the blind subjects were asked what other types of information they would like to have about intersections. Responses included a desire for a definite and instant indication of the type of traffic controls (stop signs, lights, etc.) installed at an intersection. For example, subjects reported often having to wait through two cycles of traffic lights to be certain of the presence of a left-turn signal.

This initial experiment confirmed the earlier findings of studies by Dr. Gilden of our staff regarding the surprising degree of information to be gleaned from audition by experienced and skilled blind travelers, and the importance of designing any future electronic travel aid in such a way as not to obscure the sources of this information.

Overall, the experiments served our principal goal of beginning to categorize the information used in mobility. They also helped materially in designing the next studies involving mobile subjects; the questions asked of these subjects could be much better defined as a result of our initial experience.

2. CANE USER TARGET GROUP CHARACTERISTICS

As stated by the scientific community in an NIDRR-sponsored working group for the National Research Council, 1984, an urgent need in the field is for better identification and characterization of the target group before new electronic travel aids can be intelligently designed.

We have completed and analyzed an initial pilot study to this end in collaboration with Mr. Mike Cole and his staff at the Living Skills Center, San Pablo, California.

An analysis was performed on the mobility skills of 15 totally blind clients of the Living Skills program. Blind individuals go through the program after leaving the school system to improve their independence and daily living skills (including mobility) before entering the job market. Although not a cross-section of the overall blind

community, the population studied was judged to be a reasonable representation of young blind persons who have been through the public and residential school systems (during which time all had received mobility training). The study data were the observations of the experienced mobility instructors at the Living Skills Center, and were based on the standard mobility evaluations undergone by clients of the Center. Etiological information was based on client medical records.

Table 1. Etiologies of Blind Clients

Vision:	
Retinopathy of prematurity	(7)
Diabetes	(1)
Optic dischypoplasia	(1)
Optic atrophy	(1)
Optic nerve hypoplasia	(1)
Retinal detachment	(1)
Cortical blindness	(1)
Anophthalmic (Goldenhar's syndrome)	(1)
PHPV	(1)
Hearing:	
Normal binaural hearing	(13)
Bilateral hearing loss	(1)
Monaural hearing only	(1)

All mobility skills analyzed except cane technique were rated on a scale from 1 (very poor) to 5 (excellent). Table 2 indicates the number of clients falling into each category in each specific travel skill component.

Table 2. Numbers of Students Exhibiting Different Skill Levels in Mobility Tasks

TASK	SKILL LEVEL 1 (poor)	2	3	4	5 (excellent)	N/A
Level of sophistication in street crossing tasks	(7)	(0)	(1)	(1)	(5)	(1)
Degree of orientation problems	(4)	(0)	(4)	(0)	(7)	-
Spatial concepts	(4)	(1)	(2)	(2)	(6)	-
Ability to use auditory cues	(4)	(2)	(2)	(0)	(7)	-
Cane technique: Inadequate	(6)	Adequate		(6)		(1)

Discussion

It is commonly argued by the most skilled (and vocal) blind travelers that the information provided by electronic travel aids is of no value to them since they can obtain the same information by other means such as echolocation. Our results showed that this is certainly not the case for a large fraction of the pre-vocational blind, and that many (perhaps half) in this group have severe deficiencies in their mobility skills in spite of the training they receive. For example, over 50% of the clients in this survey appear to make less than optimal use of echolocation as an information gathering system for mobility, and a large fraction appear to possess deficiencies in their abilities to orient themselves and to develop and apply spatial concepts.

All clients in this survey received training in these skills; clearly not all could attain good unaided travel skill even given this training.

The survey results will assist us in putting our other mobility studies in perspective and ensure that our approach includes consideration of the different needs of the diverse population subgroups in terms of travel skills. We hope to explore further the possibilities of both improved training and improved information from the possible future travel aids which are the eventual goal of our research.

3. ADDITIONAL WORK: TRAINING STUDIES OF LONG CANE USERS

We have investigated the feasibility of using simple technical aids in the training of blind persons. Mr. Mike Cole has evaluated the utility of a simple cane positioning aid we developed in 1986. The feedback provided by the aid was found to be of limited assistance in that only a small proportion of clients could benefit from it. Therefore further work on the project was deferred in favor of other priorities.

In a second development, Dr. Bruce Blasch of the Atlanta VA RR&D Center (who is conducting studies of mobility in older persons) has tested the Remotely Activated Sound Beacon designed earlier in our laboratories, and determined it to be potentially valuable in conducting orienteering with blind individuals. We are arranging for a number of copies of this device to be produced in Dr. Blasch's laboratories for use in this task.

E. PEDIATRICS

1. PHOTOGRAPHIC VISION SCREENING METHODS

a. Significance

Our research efforts in the field of new photographic vision screening methods for infants have made major progress. Our studies over the past two years indicate that the laboratory version of the system, using a 35mm camera with a catadioptric lens, can provide useful and accurate information on the state of refraction and astigmatism of the infant eye, while also highlighting other vision problems. The new Polaroid version of the device, described below, is not intended for fine measurements but for screening use by pediatricians, giving them the capability of detecting anomalies in infants' vision during routine office visits. Both of these versions have possible applications by paramedical field teams in remote rural areas and in developing countries where medical resources are scarce. An additional version, the feasibility of which is now being explored, would widen the possible target population further by providing almost any camera with an inexpensive attachment for performing photo-screening.

b. Polaroid Vision Screener

During the current year we have completed the design, construction and calibration of the Polaroid photorefractor. The device consists of a metal periscope attachment for a Polaroid Spectra camera. The periscope directs light from the camera strobe flash to a precisely calibrated location inside the entrance pupil of the camera's optical system. As part of the design and calibration of this device, we have made an extensive radiometric assessment of possible light exposure hazards associated with photographic refraction. To our knowledge, precise measurements have not previously been made by other users or manufacturers of such devices. We were able to determine the range of conditions under which photographic refractors can be operated within ANSI safety standards. Generally speaking, if certain precautions are not taken, exposure levels can easily exceed published standards.

A second aspect of the design and calibration of the device was the development, in collaboration with Dr. Wolfgang Wesemann, of a rigorous analytic description of the optics of off-axis photorefraction. Previous theoretical treatments had only discussed the case of spherical refractive errors. Our description includes not only the spherical case, but also the photorefraction of astigmatic eyes. This analysis has relevance to the general design of any off-axis photorefractor and has pointed out specific weaknesses in a commercially available screening device.

c. Laboratory Evaluation

Initial testing in our laboratories pointed out the need for certain improvements such as the use of higher quality mirrors and

the incorporation of an LED light source on the camera to attract the infant's attention. These modifications have been incorporated. Alignment of the camera with the subject's pupil was found to be relatively critical. The optical analysis provided by Dr. Wesemann has assisted our understanding of this feature, and possible methods of reducing the effect of malalignment are under consideration. Provided correct alignment is maintained, however, successful operation is assured. The sensitivity of the device to refractive error can be set to the desired level by adjusting the occlusion of one of the mirrors. For the type of screening applications we envisage, we set the device to detect differences between eyes in excess of one and one-half diopters.

d. Field Testing

Since mid-1987, the Polaroid photorefractor has been undergoing field testing in the pediatric clinic at the Kaiser Permanente Medical Center in South San Francisco, to assess its potential utility in a pediatric office environment. We are currently screening a large group of infants under 1 year of age with the Polaroid system. Follow-up ophthalmological exams are being conducted in a double blind fashion by Charlene Hsu, M.D. Thus far, the device has proven to meet design expectations for sensitivity to refractive error. This study will continue well into 1988.

F. LOW VISION

1. HYBRID FRESNEL-CONVENTIONAL MAGNIFIER

We have completed the design and fabrication of our first prototype Fresnel-conventional low vision reading magnifier (Figure 13). The concept of this device is to combine the advantages of clarity and high contrast provided by conventional optics with the light weight and wide field of view made possible by Fresnel technology.

Conventional magnifiers used in reading by low vision patients give only a restricted field of view, dictated by the size and weight of the optics for any desired magnifying power. The magnifier occupies only the central visual field, which can create difficulties for those patients with scotomas partially or completely occluding this area. These patients may need to fixate on a point outside the magnifier in order to project the magnified image on a "good" area of retina - a difficult task. The small magnifier size also requires constant scanning, which is made more difficult by the fact that the magnified information is taken "out of context," since there is no indication of the format of surrounding text.

Figure 13. New Hybrid Fresnel/Conventional Magnifier

Large Fresnel magnifiers can overcome these problems, but the images they provide are generally regarded as optically inferior. Consequently, we designed a lens with a conventional optical center (to maximize clarity of the actual words and letters being read on the best part of the retina) and a large-diameter Fresnel surround (to provide wide field of view for ease of fixation and scanning).

In designing the parameters of the new lens, we consulted with August Colenbrander, M.D., Director of our PPMC Low Vision Clinic, who tested a large number of different possible central lenses and settled on a 5-diopter plastic lens 3-3/4 inches in diameter as representing the best compromise between size and power. This was matched to a 10-inch diameter 5-diopter Fresnel lens from which the central area was removed. The conventional lens was cemented in place in such a way as to eliminate any visible boundary between the two lenses.

The resulting lens appears to satisfy the required optical specifications, and initial testing is now under way using the facilities of the Low Vision Clinic to determine the utility of the concept for different patients. Preliminary impressions suggest the new concept may be particularly useful for viewing of maps and large drawings, which currently present problems for low vision patients.

2. ILLUMINATION PROBLEMS IN VISION

We are well along in the design and fabrication of two classes of illumination device using new lighting technologies to aid the partially sighted. This work is being carried out in collaboration with Alan Lewis, O.D., Ph.D., who has joined our staff for a one-year sabbatical.

a. Battery-Powered Multi-Purpose Lighting System

We have designed a battery-powered, low-voltage supplementary lighting system which incorporates the quartz-halogen MR16 technology (and, upon availability, the MR11). These 12-volt systems employ precision reflectors which are available in several beam patterns and which utilize dichroic coatings to alleviate much of the infrared problem common with conventional incandescent sources. The compact, lightweight and efficient system is suitable for mounting on a head frame, loupe, or hand magnifier to provide localized illuminance of up to 20,000 lux at a working distance of 2 feet. The precision optics give excellent beam control and therefore minimize glare to others.

MR16 lamps are suitable for powering with 12-volt nickel-cadmium rechargeable batteries such as those used in video cameras. Depending on the size of the battery, a useful duration of up to 60 minutes of constant use can be achieved before recharging. A self-contained, 5 ampere-hour battery/recharger is available from Radio Shack for under $60 and is suitable for operating the illumination system.

Testing indicates that the 20-watt lamp is probably sufficient for most low vision purposes; therefore, the MR11 lamp (available only in a 20-watt version), with its significantly smaller size (about half the diameter and weight) and bayonet base, will almost certainly become the lamp of choice in this application. As a further advantage, the MR11 is totally enclosed within a glass envelope and therefore safer from quartz bulb breakage than is the exposed-lamp MR16.

Initial design is now complete, and construction of a prototype illuminator is under way.

b. <u>Fiber-Optic Illuminator For Use With Hand-Held and Stand Magnifiers</u>

Low vision patients who rely on short focal-length visual aids have great difficulty obtaining sufficient illuminance on the visual task because conventional lighting systems are blocked either by the device itself or by the user's own body shadow. While battery-powered incandescent or fluorescent systems have been used in some magnifiers to help alleviate this problem, they often provide insufficient light for persons with high illuminance requirements and introduce veiling reflections which obscure specular tasks.

We have synthesized a preliminary design which uses a highly efficient 70-watt metal-halide source (>70 lumens/watt), with fiber-optics to deliver the light to the magnifier, and a three-mirror optical system in combination with a Fresnel lens to distribute the light on the work surface. No prototype has been constructed because the lamp to be used was withdrawn from the market in May 1987 after operating life and color characteristics were deemed by the manufacturer to be less than anticipated. Alternative sources of supply are now becoming available - Sylvania has introduced a physically identical 100-watt lamp - and we expect to resume development of the system when this becomes available.

This new lighting technology is capable of producing very high illuminances, excellent color, and is glare-free. The short wavelength light content of the metal-halide lamp is far greater than that of the incandescent lamp, which helps restore vision in the "blue" range which has been lost by the yellowing of the aged human lens. Most important is that the very small size of the metal halide arc allows fiber-optics to be employed to remove the source itself from the immediate vicinity of the user, thus eliminating the major safety hazard and annoyance of heat from incandescent lamps. Our system design allows substitution of a quartz-halogen incandescent lamp in place of metal-halide where lower cost is more important than is high luminous efficiency.

3. LOW-CONTRAST ACUITY CHARTS

We have begun the development of an innovative low-contrast acuity chart, designed to give the clinician a rapid measure of visual contrast sensitivity. Detection of low-contrast and low-luminance

targets are important parameters in assessing the functional vision in the partially sighted. These functions are thought to be particularly important in mobility and other daily tasks. Currently, the measurement of these performance factors requires multiple tests of some complexity.

Our new concept combines the measurement of low-contrast and low-luminance vision performance into one eye chart of proprietary design, allowing a single and rapid test of the patient's visual performance under conditions of reduced contrast and luminance. Preliminary tests of the new concept have proven successful, and fabrication of a new version for larger scale testing is under way.

4. PILOT STUDY IN LOW VISION READING

We have assembled the necessary apparatus and facilities to conduct reading studies on low vision patients using the experimental paradigms developed by Gordon Legge, Ph.D. Our goal is to extend Legge's work to a wider low vision population, especially including those with macular disease, and to explore the interaction of reading performance with a variety of other variables.

Most low vision specialists agree that standard, high-contrast visual acuity tests do not adequately predict performance on more complex visual tasks. This is especially true when the visual loss includes field defects adjacent to the foveal region which have been caused by a retinal disease or by laser treatment to stabilize the condition. Our pilot study compares visual acuity, measured with conventional charts and with several low contrast versions constructed at SKERF (see section 3 above), to two measures of reading performance:

a. Reading speed is measured by means of the Pepper Visual Skills for Reading Test (VSRT) which presents unrelated words of various lengths (1-7 letters) on fixed cards at acuity levels above the subject's threshold. Score is given as reading rate (words/min) after correction for errors.

b. Reading speed is measured by the maximum speed that a line of unrelated words can be scanned across a television monitor (VTEK closed-circuit television magnifier) without inducing errors. All words on a given line contain the same number of letters; word lengths range from 3 to 9 letters. Score is given as scan rate for a given word length. The letter size can be controlled on the monitor and is set just above the subject's acuity threshold for testing. Scan rate is controlled with a motor-driven X-Y scanning table.

Results to date on eight subjects indicate that, although there is no exact predictive relationship between reading speed and acuity, persons with lower acuity do generally read more slowly - even when the size of the reading material is adjusted to compensate for the lowered acuity. Larger-scale testing of a greater number of patients would, however, be needed before any firm conclusions regarding high- and low-contrast acuities, visual pathologies, and reading speeds could be drawn.

G. <u>INFORMATION DISSEMINATION</u>

1. REHABILITATION ENGINEERING SERVICE

We have established a privately funded Rehabilitation Engineering Service to provide custom-designed sensory aids for the blind and low vision populations on a user-fee basis. The first devices from this program have been successfully designed, fabricated, and delivered, and expansion of the program is under way. We have secured the cooperation of a software developer who has agreed to act as a subcontractor for this service, and we are investigating the inclusion of an electronics training program on a fee-for-service basis (based on our experience with our earlier Blind Technicians' Training and Research Program). This privately funded Rehabilitation Engineering Service has also supported the printing and distribution costs for the <u>Smith-Kettlewell Technical File</u>.

We anticipate increased demand for this service as the provisions of the 1986 Rehabilitation Act Amendments are implemented more fully by state departments of rehabilitation.

2. REC DOCUMENTATION AND PUBLICATION REVIEW

We have recently completed our review of the documentation and publication needs of the REC. Under the resulting streamlined REC project documentation plan, as each sensory aid design is completed, we will develop a full set of documentation, including schematics and descriptions of necessary construction methods. A print version of this documentation will be added to our files of project documentation for distribution to manufacturers, sighted individuals, and agency representatives wishing to construct these devices.

The same documentation, translated to braille and recorded speech format, will be compiled quarterly and made available to blind consumers in the form of the <u>Smith-Kettlewell Technical File</u>. (To make the documentation fully accessible to the blind, each circuit schematic must be converted to a verbal circuit description.) The printing and distribution costs of this publication are covered by subscriptions and private funding. Our surveys and projections indicate that over 400 Smith-Kettlewell-designed sensory aids have been constructed by or for blind consumers through the Technical File. Back issues are kept on hand to fulfill requests for user-accessible documentation of particular projects.

More general information about our sensory aids development program and its latest results will be disseminated to the sighted community of agencies and professionals working for the blind in the form of our Annual Progress Report; anyone requiring more technical detail will have full access to our print, braille, or cassette documentation (as described above) upon request. In addition, we intend to continue publishing our research results in targeted scientific and professional journals.

Presentations

Brabyn, J. Lecture: "Mobility Problems of the Elderly." University of California, Berkeley School of Optometry, Lecture Series on Functional Impact of Sensory Loss With Aging; October 8, 1987.

Brabyn, J. Keynote Speech: "Let's Not Reinvent the Wheel." Mississippi State R&T Center/AFB National Working Seminar on Job Modification for Blind and Visually Impaired Persons, Orlando, FL; April 8-10, 1987.

Gerrey, W. Lawton Elementary School, San Francisco, Testing Prototype Educational Lab Activities to Facilitate the Transition into Courses in Basic Electricity and Magnetism, six visits to 5th grade class from March to May, 1987.

Gerrey, W. Presentation: "Posing the Problem to the Rehabilitation Engineer." Mississippi State R&T Center/AFB National Working Seminar on Job Modification for Blind and Visually Impaired Persons," Orlando, FL; April 8-10, 1987.

Gerrey, W. and Fowle, T. Presentation and Demonstration: "Electronic Sensory Aids," San Francisco Lighthouse for the Blind; July 20, 1987.

Gilden, D. "A Robotic Hand as a Communication Aid for the Deaf-Blind." Twentieth Annual Hawaii International Conference on System Sciences, Kailua-Kona, Hawaii; January 9, 1987.

Gilden, D., "Time and Time Again, Say it Without Feeling: Two New Devices for Deaf-Blind People." RESNA Tenth Annual Conference on Rehabilitation Technology, San Jose, CA; June 23, 1987.

Gilden, D. "Commercial and Prototype Educational Aids for Blind Children." Teacher/Therapist In-Service, Redding, CA; September 4, 1987.

Gilden, D. "Sensory Aids from the Rehabilitation Engineering Center at the Smith-Kettlewell Eye Research Foundation." NASA Planning Conference, Oxnard, CA; September 28, 1987.

Gilden, D. "A Decade of Sensory Aids for Visually Impaired People." Conference on Computer Technology/Special Education/Rehabilitation, California State University, Northridge; October 16, 1987.

Gilden, D. "Reducing Manual Signs and Alphabet for Special Learners: For Ease of Learning and for Simplifying Computer Technology Requirements." Conference on Computer Technology/Special Education/Rehabilitation, California State University, Northridge; October 17, 1987.

Jampolsky, A. "Performance Research." RESNA Tenth Annual Conference on Rehabilitation Technology, San Jose, CA; June 23, 1987.

Loughborough, W. "New Touch-Pad Computer Access System for the Blind." Conference on Computer Technology/Special Education/Rehabilitation, California State University, Northridge; October 17, 1987.

Publications

Brabyn, J.A. "Sensory Aids Invention and Reinvention: The Influence of the Market on Developers." Sensus, Sensory Aids Foundation, Spring 1987, 12-15.

Brabyn, J.A. and Alden, A. "Electronic Braille Notetakers for the Blind." Proceedings, RESNA Tenth Annual Conference on Rehabilitation Technology, San Jose, CA, June 1987, 454-455.

Brabyn, J.A. "Smith-Kettlewell Rehabilitation Engineering Center Progress Report to 1987." Veterans Administration Rehabilitation R&D Progress Report, 1987. In press.

Brabyn, J.A. "Assistive Devices for the Blind and Visually Impaired." Wiley Encyclopedia of Medical Devices and Technology. In press.

Brabyn, J.A. "New Aids to Computer Access and Communication for the Blind." Proceedings, IEEE/EMBS 8th Annual Conference, Ft. Worth, TX, November 7-10, 1986, 1813-1815.

Day, S.H., Orel-Bixler, D.A., Norcia, A.M. "Abnormal Acuity Development in Infantile Esotropia." Investigative Opthalmology Visual Science, 1987, Vol.28, No. 3, 102.

Gerrey, W. "Soldering With Modern Techniques and Materials." Proceedings, Tenth Annual Conference on Rehabilitation Technology, San Jose, CA, June 1987, 464-466.

Gilden, D. "A Robotic Hand as a Communication Aid for the Deaf-Blind." Proceedings of the Twentieth Hawaii International Conference on System Sciences, Health Care System Special Topic, January 1987, Vol. 3, 264 - 274.

Gilden, D. "Time and Time Again, Say it Without Feeling: Two New Devices for Deaf-Blind People." Proceedings of the Tenth Annual Conference on Rehabilitation Technology, June 1987, 422 - 425.

Gilden, D. "A Chat with Alan Brightman, Manager, Office of Special Education, Apple Computer, Inc." The DCCG Real Times, The Newsletter of the Disabled Children's Computer Group, Fall 1987, 2 - 3.

Gilden, D. "A Decade of Sensory Aids for Visually Impaired People." Proceedings from the California State University, Northridge, Conference on Computer Technology/Special Education/Rehabilitation, 1987, in press.

Gilden, D. "Reducing Manual Signs and Alphabet for Special Learners: For Ease of Learning and for Simplifying Computer Technology Requirements." Proceedings from the California State University, Northridge, Conference on Computer Technology/Special Education/Rehabilitation, 1987, in press.

Gilden, D. "Speaking in Hands." Soma Magazine. October 1987, Vol. 2, No. 3, cover plus 6 - 14.

Gilden, D., Brodale, J. Announcement design: "Double Doings in Montreal!" Conference program from The California State University, Northridge, Conference on Computer Technology/Special Education/Rehabilitation, October 15 - 17, 1987

Norcia, A.M., Tyler, C.W., Hamer, R.D. "Development of Contrast Sensitivity in Human Infants." Investigative Ophthalmology and Visual Science, 1987, in press.

Norcia, A.M., Tyler, C.W., Piecuch, R., Clyman, R., Goldstein, J. "Visual Acuity Development in Normal and Abnormal Preterm Human Infants." Journal of Pediatric Ophthalmology and Strabismus, 1987, Vol. 24, No. 2, 70 - 74.

Orel-Bixler, D. and Norcia, A.M. "Differential Growth of Acuity for Steady-State Pattern Reversal and Transient Pattern Onset-Offset VEPs." Clinical Vision Sciences, in press.

Schenkman, B. "The Effect of Receiver Beamwidth on the Detection Time of a Message from Talking Signs, An Auditory Orientation Aid for the Blind." International Journal of Rehabilitation Research, 1986, 9 (3), 239-246.

Sherman, K.R. "Activation of Vestibulo-Ocular Reflex Adaptation." Supplement to Investigative Ophthalmology and Visual Science, 1987, Vol. 28, No. 3.

Sherman, K.R., Keller, E.L., and Stark, L. "Simulations and Sensitivity Analysis of the Vestibulo-Ocular Reflex," IEEE Transactions on Biomedical Engineering, September 1987, Vol. BME-34, No. 9.

Tyler, C.W., Norcia, A.M., Hamer, R.D. "Two Mechanisms Revealed by Sweep VEP Contrast Functions in Infants." Optical Society of America Technical Digest, 1987, 24 - 27.

Tyler, C.W., Norcia, A.M., Hamer, R.D. "On the Existence of Contrast Threshold in Infants. Investigative Ophthalmology and Visual Science, 1987, Vol. 28, No. 3, 4.

Advisory Groups and Professional Organizations

Brabyn, J. Chairman, NIH Special Study Section for Small Business Innovative Research.

Brabyn, J. Member, Scientific Advisory Board, Veterans Administration Rehabilitation Research and Development Service.

Gilden, D. Member, Board of Directors, Disabled Children's Computer Group, Berkeley, California. (The DCCG is serving as a model for similar organizations being set up in each state by Apple Computer, Inc.)

Gilden, D. Co-Chairman, Special Interest Group on Sensory Aids, RESNA, 1987-1988.

Gilden, D. Member, Board of Directors, San Francisco International Toy Museum, San Francisco, California.

Jampolsky, A. Member, National Eye Advisory Council.

Workshops

Brabyn, J. Participant: NASA Low Vision Workshop, NASA Ames Research Center, February 5-6, 1987.

Brabyn, J. Participant: NIDRR Workshop on the Development, Production and Marketing of Technological Devices for Disabled Americans, Washington, D.C., July 13-14, 1987.

Gerrey, W. Participant: NIDRR/GSA Workshop on Accessibility Guidelines for Electronic Equipment, Washington, D.C., July 15-16, 1987 and August 26-27, 1987.

Gilden, D. Invited Participant: Leadership Symposium, Carroll Center for the Blind, Newton, Massachusetts; November 18-20, 1986.

Gilden, D. Participant: NASA Planning Conference, Oxnard, California; September 28-30, 1987.

Exhibits

Gilden, D., Gerrey, W., Williams J. "Educational and Vocational Sensory Aids for the Blind," California Transcribers and Educators of the Visually Handicapped (CTEVH), Sacramento, California; March 19-22, 1987.

Gilden, D., Brabyn, J.A., Gerrey, W., Williams, J., Fowle, T., Sherman, K., Sutter, E., Tran, T.D.T., Alden, A., Loughborough, W., Winderl, M. "Vocational, Educational, and Communication Aids from the Smith-Kettlewell Rehabilitation Engineering Center." RESNA, Association for the Advancement of Rehabilitation Technology, San Jose, California; June 19-23, 1987.

Gilden, D. "Educational Technology for Blind Children." The Disabled Children's Computer Group Open House, Berkeley, California; October 11, 1987.

Interviews and Panels

Gilden, D. California State Department of Education Satellite Teleconference: "Technology in Special Education," May 14, 1987.

Gilden, D. San Jose Mercury News, "Creative Computers Enable Handicapped to Take Control," RESNA Conference, San Jose, California; June 21, 1987.

REC STAFF

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Ann Lewis, Secretary

Charlene Keh, General Office Assistant
(September 1987 to present)

Maureen Carrig, General Office Assistant
(September 1986 to September 1987)

Joan Dalla, Secretary
(September 1987 to present)

Diana Mousley, Secretary
(To August 1987)

<u>**NOTE-A-BRAILLE QUESTIONNAIRE**</u>

The following numbered questions have multiple answers from which you can choose your responses. Please feel free to choose more than one answer per question. Your answers may be checked off in pen or pencil on the questionnaire, or they may be written on a separate sheet, either typed or in Braille. If a separate sheet is used, write the number of the question first; then follow it with with the letters of your answers.

1. **How did you obtain your Note-a-Braille?**

   A. On loan from Smith-Kettlewell.

   B. Fabricated my own.

   C. Had one fabricated by a third party.

2. **How would you best characterize your experience with the Note-a-Braille?**

   A. Casual experimentation.

   B. Used for generating one or more serious files or documents.

3. **What do you see as the most useful application of the Note-a-Braille?**

   A. Classroom notes.

   B. Meeting notes.

   C. Writing papers away from your computer.

4. **The physical size of the Note-a-Braille was primarily determined by the keyboard configuration. Regarding size of the device:**

   A. Would you prefer a smaller size with a commensurate reduction in keyboard size?

   B. Would a longer unit--making the device more comfortable for supporting on the lap--be worth considering?

   C. Is the current size, 5 by 7 inches, to your liking?

5. **With perhaps a 10% increase in cost, the Note-a-Braille's keys could be altered. (The ones chosen are very inexpensive.) Regarding the input keys:**

   A. Although the keys might feel more "spongy," they should be made quieter.

B. Though their "travel" may be reduced, the keys should be of lower profile (thinner).

C. In the interest of cost, the current choice of keys is fine.

6. **Because the Note-a-Braille's internal memory is made to store 8-bit codes, the keyboard was designed to accept "8-dot Braille" entries; this permits single-stroke equivalents of all the ASCII characters to be created. On the other hand, a 6-dot keyboard would comprise a smaller keyboard, and the Note-a-Braille could be made smaller; this 6-dot keyboard would necessitate making double key strokes for upper-case letters and control characters, which may not be a serious disadvantage if you have a good Braille Grade II "back translator."**

   A. I like the keyboard as is, permitting single-stroke uppercase letters to be entered.

   B. Reducing the physical size by going to a 6-key keyboard would be desirable.

7. **One of the reasons for making the Note-a-Braille as simple as it is was so that it could easily be duplicated by individual builders.**

   A. Is this a consideration worth retaining?

   B. Although increased sophistication would necessitate turning the project over to one producer, this makes no difference to me, as long as costs are kept low.

8. **It was felt, for the sake of simplicity, that editing functions would best be handled on your computer, not in the Note-a-Braille itself. Further, it was reasoned that inclusion of editing features might even be dangerous to files, as long as no text feedback is included. In the production model:**

   A. The device should be redesigned with a microprocessor so that primitive editing functions could be incorporated.

   B. The editing functions on my computer are so effective that I would rather do it there, not on the portable device.

9. **In order to keep the design straightforward and as simple as possible, no provision was made for "backspacing" (for single error correction). In the production model, a backspace key:**

   A. Would be essential.

   B. A desirable feature for no increase in cost.

C. Not important, since use of my main computer's editor is easy enough.

10. **The only "feedback" in the Note-a-Braille consists of faint clicks from an internal speaker to tell the user that the device is working; these clicks turn into tones which indicate the presence and length of files when the user steps through blocks in memory. The loudness of these signals was chosen to be low for preservation of the battery (they constitute the principal drain when the Note-a-Braille is in use).**

    A. The "clicks" and "beeps" are not loud enough, and should be increased in volume, even if this means that the battery drain is doubled.

    B. The clicks are OK as is, with battery drain being a worthy consideration.

11. **At present, the only signal that the internal memory is about to run out is that the feedback clicks start occurring on every other key stroke. If this indication is ignored, the user will start running over the beginning of the first file after 512 characters.**

    A. This end-of-memory signal is insufficient.

    B. This end-of-memory signal is unobtrusive and good enough.

    C. A hard lockout should prevent the user from cycling into the beginning of memory.

    D. No hard lockout should prevent overwriting at the beginning of memory, so that entry of my new material will always be assured.

12. **The inclusion of a readback system into the Note-a-Braille would effect the product in two ways. Speech output would no doubt add $200 to its cost; a readback system of Braille would add perhaps $800 to the cost. For either output, the battery would have to be increased in size, and frequent recharging or replacing would be necessary.**

    A. Lack of a readback feature is disconcerting; inclusion would be worth the cost and larger battery.

    B. As long as I am sure the device is working, I can get used to the lack of text readback, and this is sufficient as is.

13. **The size of the memory in the Note-a-Braille was determined by the availability of low-cost memory chips at the time of design. As new memory chips come on the market, expansion should be possible.**

A. The amount of memory in the current unit is sufficient, and expansion at an increase in cost is unnecessary.

B. I have run out of memory one or more times; expansion at a reasonable increase in cost would be a necessity for the eventual product.

C. Memory expansion, even with an increase in physical size of the device, is desirable.

14. As it turned out, the Note-a-Braille was designed concurrently with other portable devices: The "Pocket Braille," the "PortaBraille," the "Braillevox," and an English product called the "Pocket Brailler."

A. The Note-a-Braille has features and possible cost advantages which serve a need not filled by other devices.

B. Other devices are sufficient to serve the need for a portable note taker.

15. Please write further comments here: